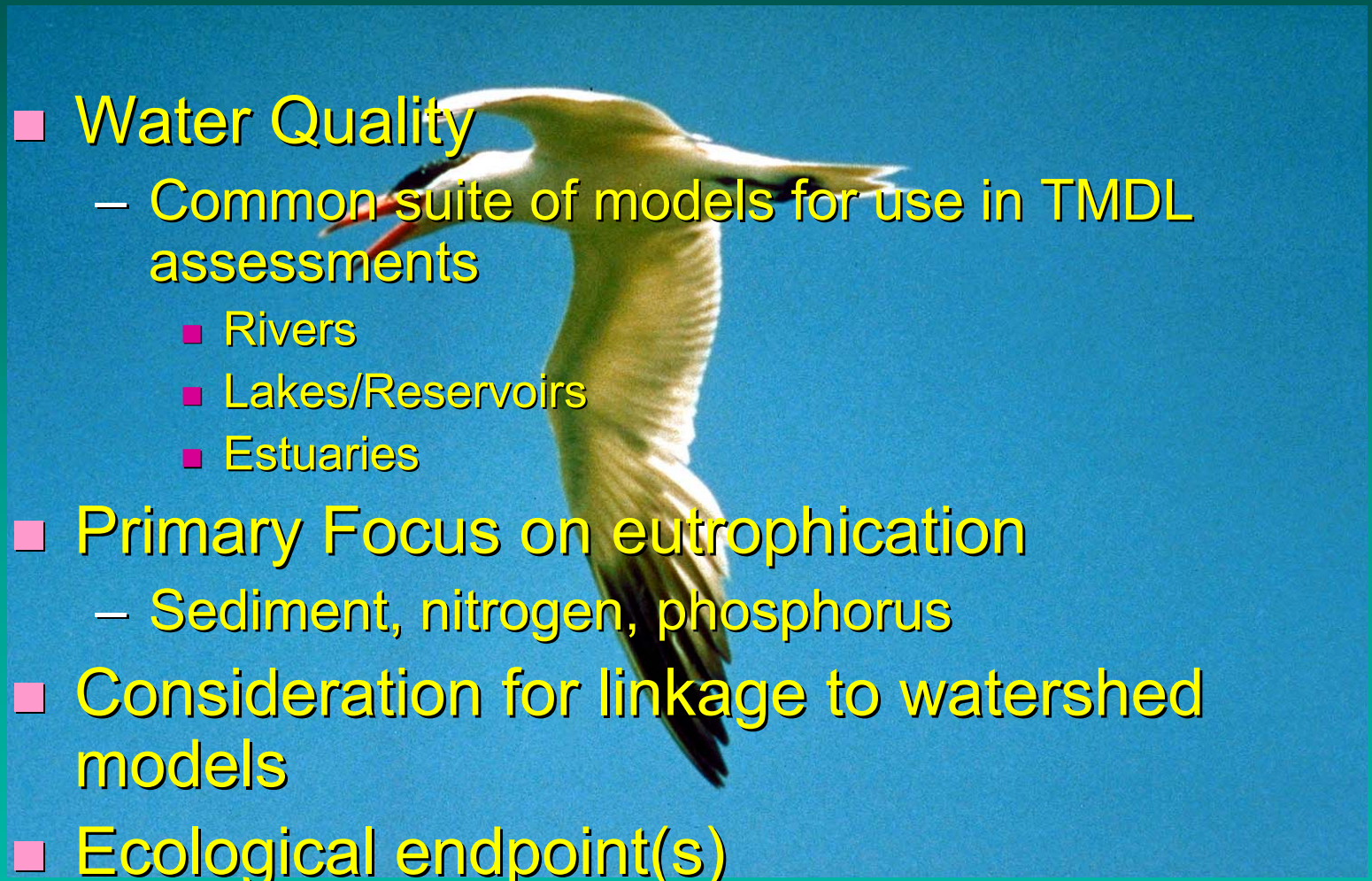
Selection of Water Quality Models for use in Total Maximum Daily Load (TMDL) Analyses

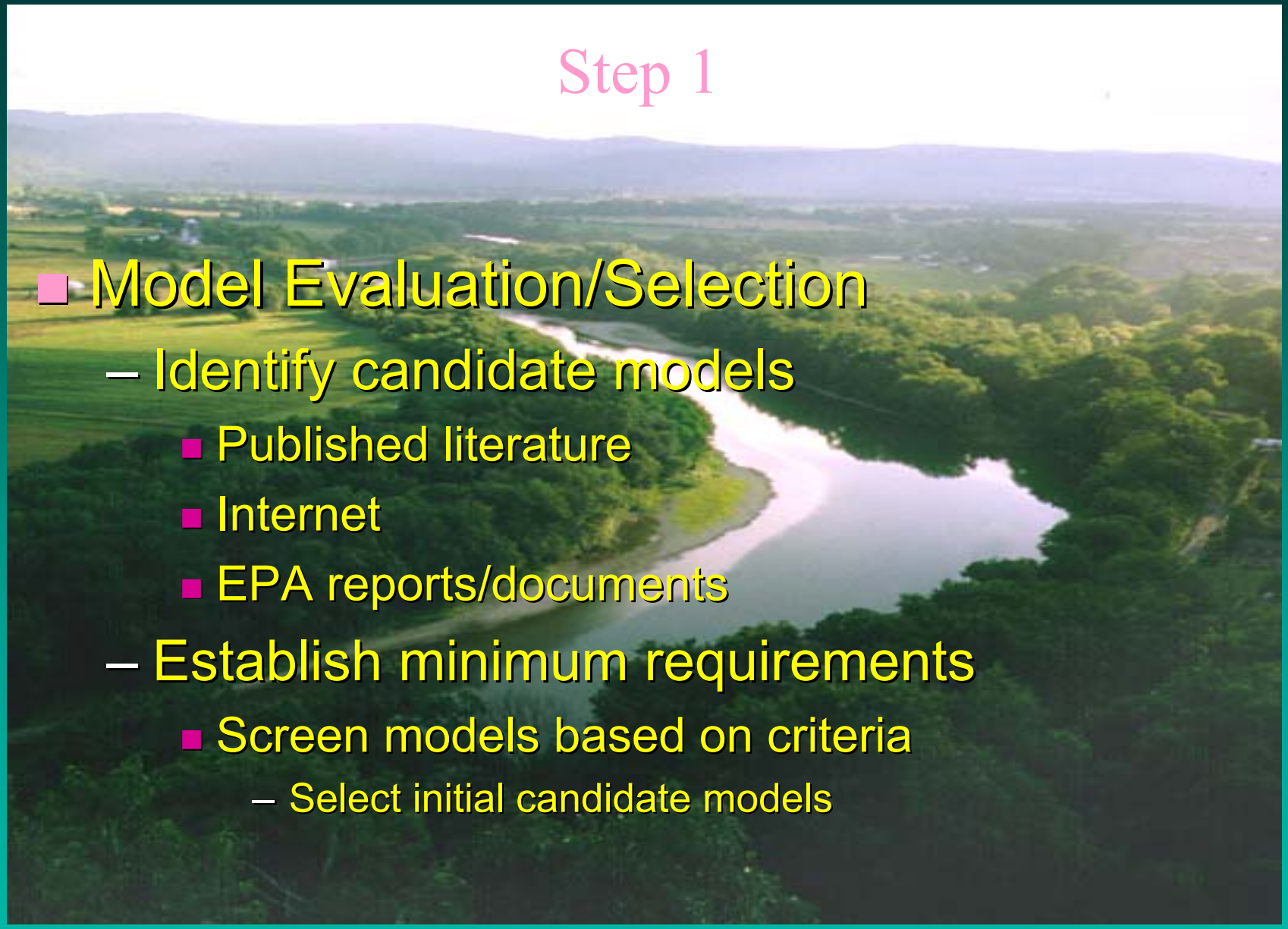
Robert F. Carousel
U.S. EPA Office Research and Development
National Exposure Research Laboratory
Gulf of Mexico Program
Stennis Space Center, MS. 39529
ph.: 228-688-1663
Fax: 228-688-2709
Email: carousel.robert@epamail.epa.gov

TMDL Model Needs



- Water Quality
  - Common suite of models for use in TMDL assessments
    - Rivers
    - Lakes/Reservoirs
    - Estuaries
- Primary Focus on eutrophication
  - Sediment, nitrogen, phosphorus
- Consideration for linkage to watershed models
- Ecological endpoint(s)

Step 1



- Model Evaluation/Selection
  - Identify candidate models
    - Published literature
    - Internet
    - EPA reports/documents
  - Establish minimum requirements
    - Screen models based on criteria
      - Select initial candidate models

Sources

- Modeling Watershed Water quality (Donigian et. al., 1995
- EPA IMES (Versar, 1996)
- Evaluating Computer Models (WEST, 1996)
- EPA's Compendium Tools (Shoemaker, et al., 1997)
- Hydrodynamics and Water Quality Modeling (Martin and McCutcheon, 1998)
- Technical Evaluation of Existing Models (Tetra Tech, 1997)
- USGS SMIG web page, 1999

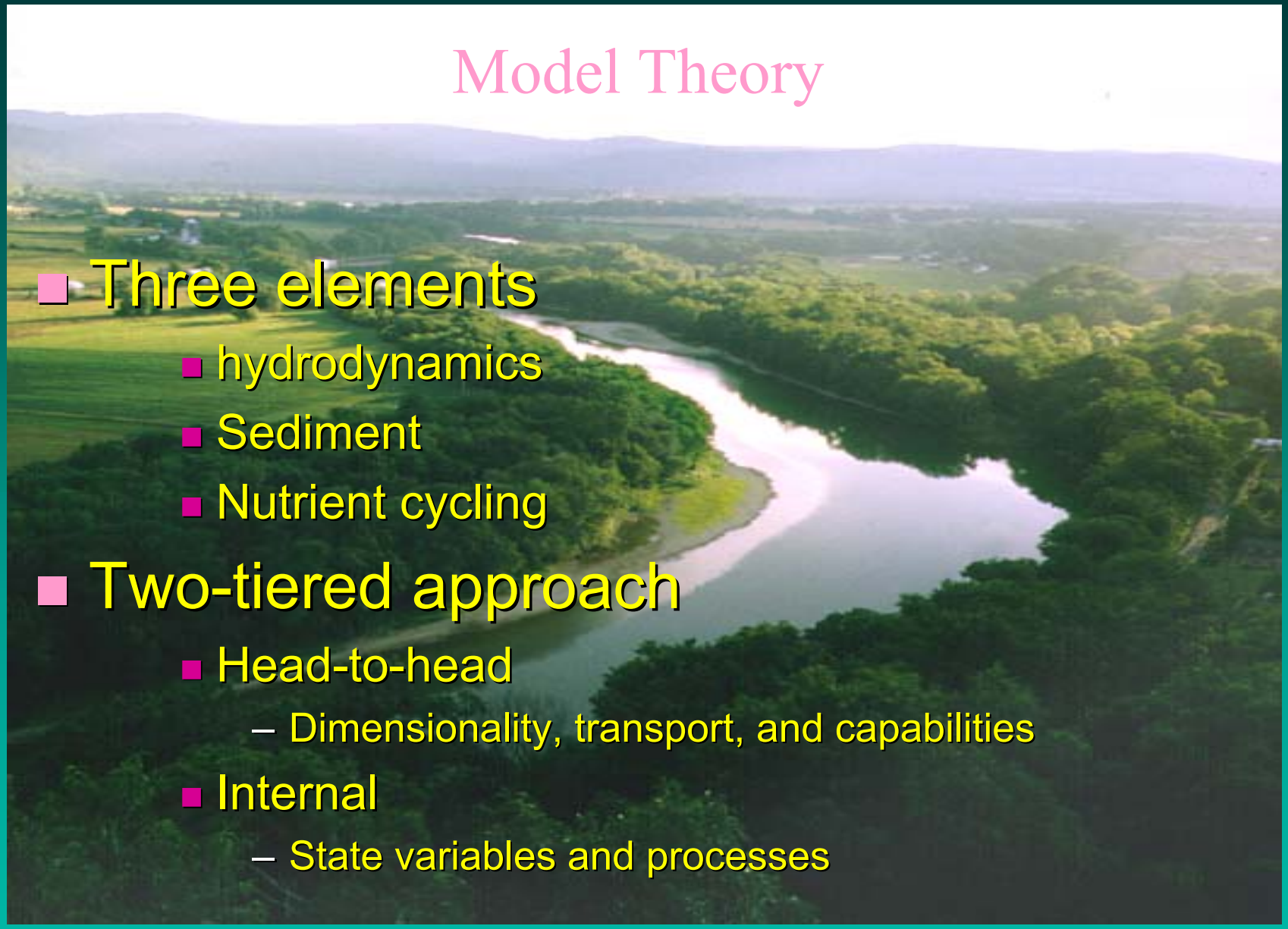
Minimum Requirements

- Well developed representation sediment, nutrients, and some plankton species
- Internally or successfully coupled to a hydrodynamic model
- Documentation of algorithms, operational instructions and flow of execution
- Have had at least 3 applications during the last 10 years with one other than the developer
- Code should be non-proprietary or must be a one-time purchase without a run-time license
- PC-compatible platform is required
- For reservoir and estuary models, multi-dimensional capability

Step 2

- Perform detailed evaluation candidate models
  - Model theory
  - Translation of theory into mathematical representation
  - Testing/publication
  - Model code and architecture
  - Availability
  - Technical support/expertise
  - Linkage to watershed models

Model Theory

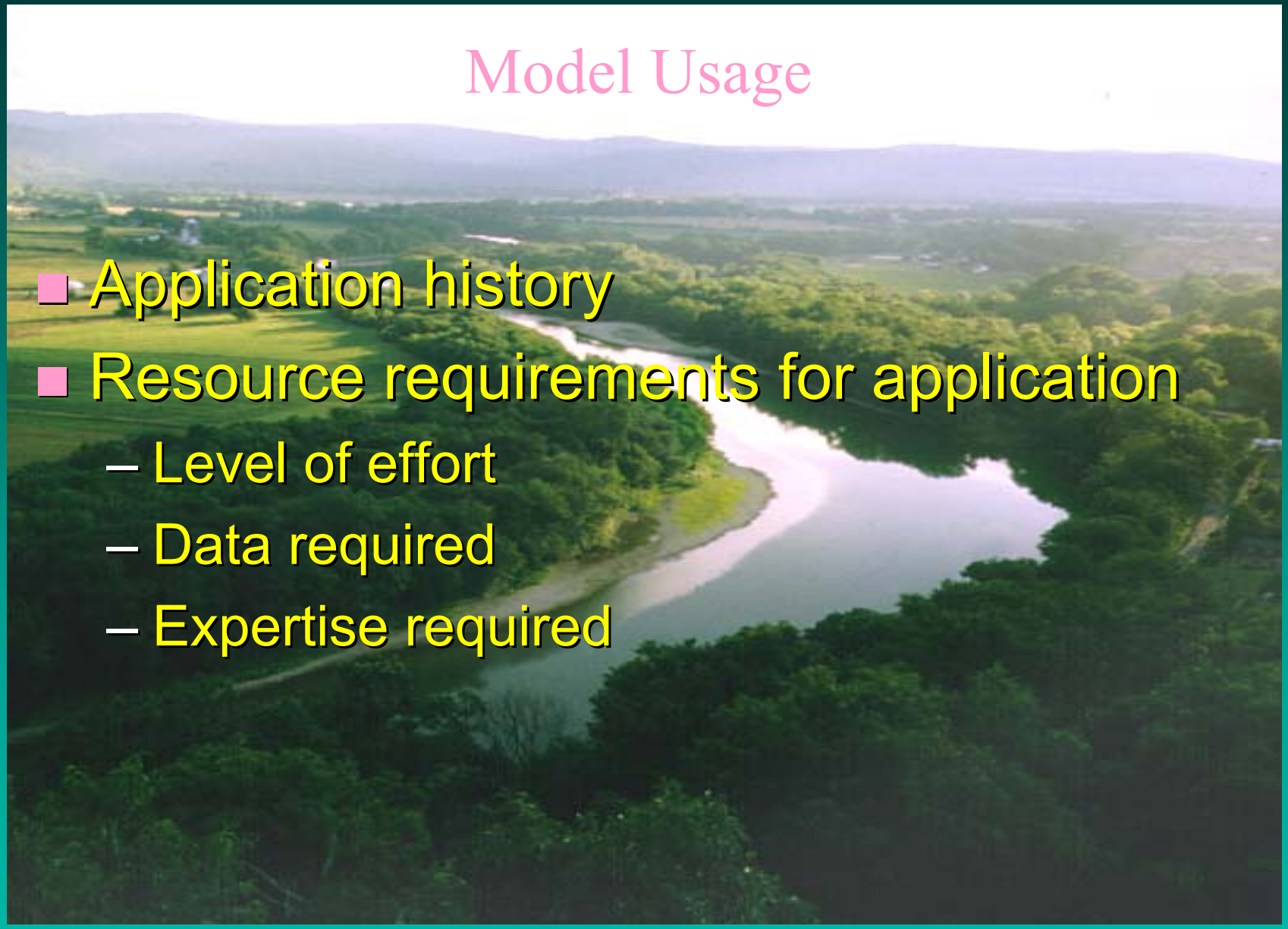


- Three elements
  - hydrodynamics
  - Sediment
  - Nutrient cycling
- Two-tiered approach
  - Head-to-head
    - Dimensionality, transport, and capabilities
  - Internal
    - State variables and processes

Model Support

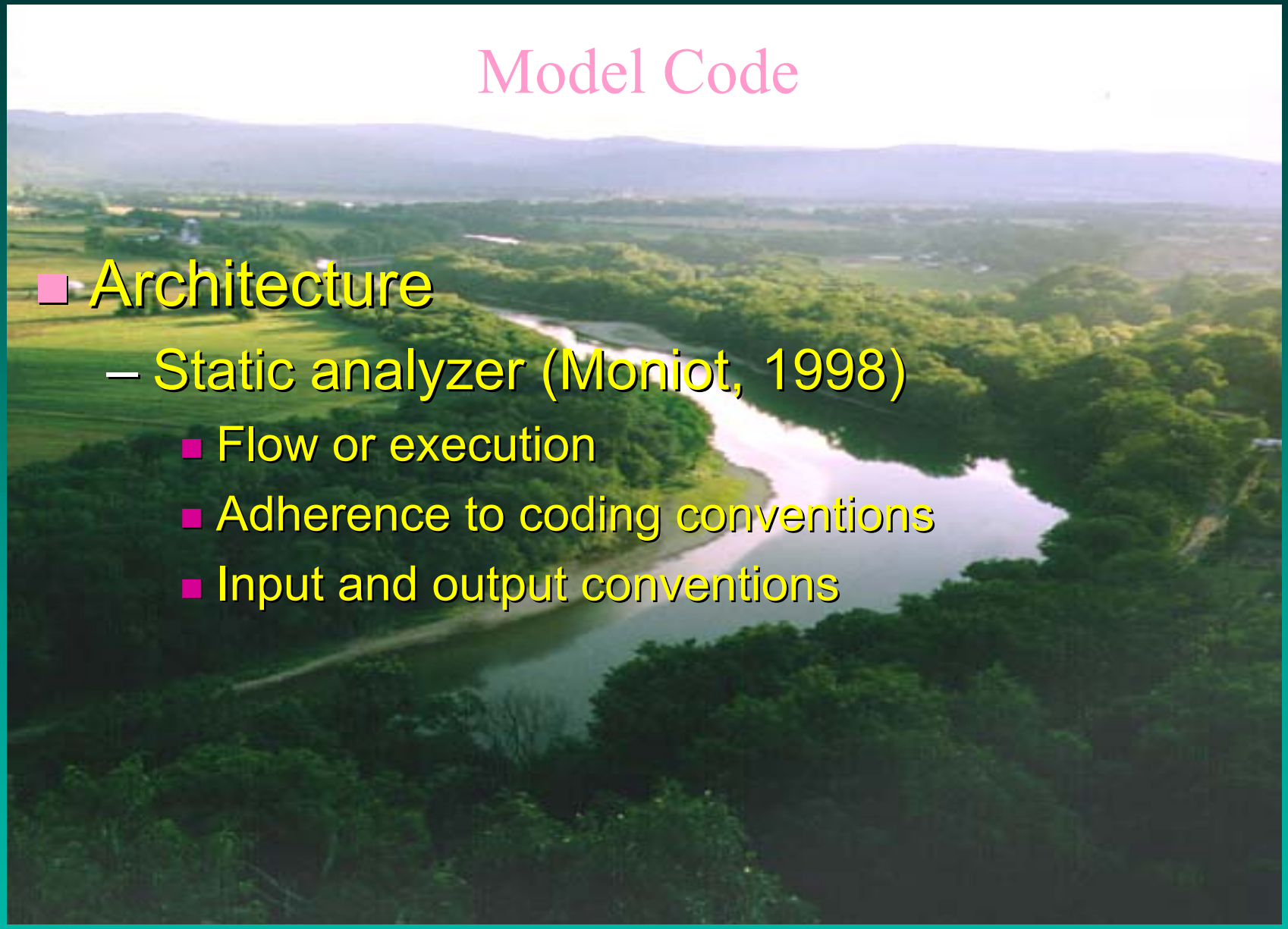
- Availability of developer or sponsor
- User groups
- Workshops
- Web sites
- Recurring conference/symposia

Model Usage



- Application history
- Resource requirements for application
  - Level of effort
  - Data required
  - Expertise required

Model Code



- Architecture
  - Static analyzer (Moniot, 1998)
    - Flow or execution
    - Adherence to coding conventions
    - Input and output conventions

Model Availability

- Existence of code
- Code obtainable
- Willingness developer to work on further development and enhancement

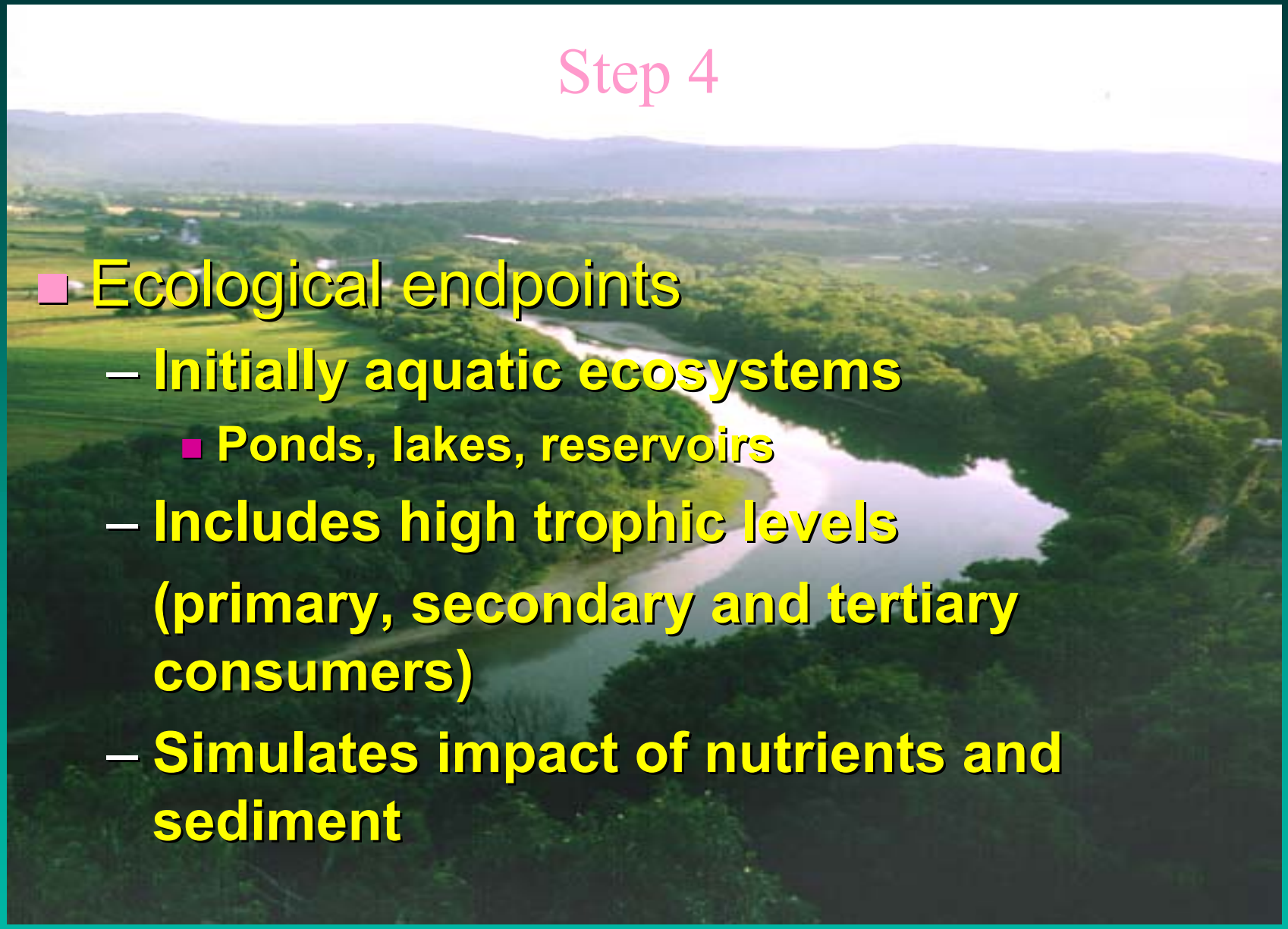
Step 3

- Recommend models for TMDL Applications
- ***Total of 80 models identified***
  - ***50 models eliminated in prescreening***
- ***Remaining 30 models***
  - ***23 removed from consideration***
    - ***Inadequate representation of water quality variables and processes or because lacked dynamic hydraulics***
    - ***Unavailability of code***
    - ***Several reservoir/estuary models failed because of lack of multi-dimensionality***
    - ***Linkage issues with HSPF***

Recommended Models

- Mathematical models for TMDL Applications
  - *CE-QUAL-RIV1 – high variability rivers and streams*
  - *CEQUAL-W2 – stratified lakes*
  - *CEQUAL-ICM – estuary (3dimensional)*
  - *EFDC – estuary (multidimensional)*
  - *WASP – general applied rivers, lakes, estuaries*
  - *HSPF RCHRES – high variability rivers and streams*
  - *GLLVHT – estuary (multidimensional)*
    - *Proprietary code*

Step 4



- Ecological endpoints
  - Initially aquatic ecosystems
    - Ponds, lakes, reservoirs
  - Includes high trophic levels (primary, secondary and tertiary consumers)
  - Simulates impact of nutrients and sediment